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Artificial Intelligence and Human Resources Management: A Bibliometric Analysis

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ABSTRACT

Artificial Intelligence (AI) is increasingly present in organizations. In the specific case of Human Resource Management (HRM), AI has become increasingly relevant in recent years. This article aims to perform a bibliometric analysis of the scientific literature that addresses in a connected way the application and impact of AI in the field of HRM. The scientific databases consulted were Web of Science and Scopus, yielding an initial number of 156 articles, of which 73 were selected for subsequent analysis. The information was processed using the Bibliometrix tool, which provided information on annual production, analysis of journals, authors, documents, keywords, etc. The results obtained show that AI applied to HRM is a developing field of study with constant growth and a positive future vision, although it should also be noted that it has a very specific character as a result of the fact that most of the research is focused on the application of AI in recruitment and selection actions, leaving aside other sub-areas with a great potential for application.

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Artificial Intelligence: A New Paradigm in Human Resource Management

The supposed “Fourth Industrial Revolution” or “Industry 4.0” has introduced intelligent technologies like Artificial Intelligence (AI) (Kong et al. 2021). The increased development of information and communication technologies (ICT) allows phenomena like AI to greatly influence different parts of society (Bolander 2019) becoming one of the most relevant elements of all possible changes in various aspects of life in this era (Aloqaily and Rawash 2022)

Although different departments of multiple organizations have adopted or integrated AI-based tools, the Human Resources (HR) department still cannot implement them (Vrontis et al. 2022). Despite there being many people in the HR department of organizations that recognize the importance of applying AI, they also point out that they have not taken any actions regarding this. This is a reality that shows that even though AI in the HR area is still a developing

revolution and is mostly limited to large companies (Bolton 2018), it is already unstoppable.

Due to the relative novelty of this technology and its application in different areas of the organization, many of the scientific developments in this field have mostly occurred in recent years. For this reason, although AI has been presented as a powerful tool in HRM, academic research on the subject is not very extensive (Pan et al. 2022).

In this context, we consider that based on a bibliometric approach, the article aims to identify and analyze the connection of the AI phenomenon with the human resource management (HRM) of organizations to study (1) the level of knowledge and training of their managers, (2) the benefits and challenges in its implementation, and (3) identify the subareas with greater development and implementation in HRM.

The connection between AI and HRM allows us to establish the following research questions for this work. The first research question is related to previous AI reflections and challenges. However, authors seem unclear how AI will affect or benefit employees and societies (Mitchell and Brynjolfsson 2017). Other authors point out to the need for more data about on the speed of AI progress (Nedelkoska and Quintini 2018). Especially its impact on every HRM-related task.

RQ1. Does the scientific community consider AI to be a commonly used tool in HRM?

The second proposed question has been studied by several published works that indicate the benefits of AI technology in different HRM sub-tasks (Qamar et al. 2021).

RQ2. Does AI have a similar impact on all HRM sub-areas?

RQ3. Are employees in HR areas prepared to meet the challenges posed by AI in people management?

RQ4. Does the application of AI in HRM help to improve the company's competitiveness?

The answer to this research questions derived from the results obtained together with the discussion and the most relevant conclusions support the theorization presented in this paper. Regarding the originality of this work, this study, based on quantitative and qualitative research, from the combined use of the most relevant scientific databases, Web of Science and Scopus, allows us to focus on how IA has been integrated into organizations in HRM and its influence on the

Table 1. Definitions of Artificial Intelligence.

Authors	Definitions
(McCarthy 1956)	The science and engineering of creating intelligent machines, especially intelligent computer programs.
(Minsky 1968)	The science that deals with the development of machines capable of performing functions that a human can perform and that require human intelligence.
(Nilsson 1998)	AI is a part of computer science that focuses on machine learning, making computers act intelligently, continuously learning, and improving their performance.
(Cappelli et al. 2019)	Broad class of technologies that enable a computer to perform tasks that normally require human cognition, including decision-making.
(Stanley and Aggarwal 2019)	Development of computer systems that perform tasks that require human intelligence. The main goal of AI is to make machines more intelligent.
(Bolander 2019)	Construction of machines – computers or robots – that can perform tasks that otherwise only humans have been able to do.
(Paesano 2021)	Systems that exhibit intelligent behavior by analyzing their environment and performing actions, with a certain degree of autonomy, to achieve specific objectives.

approach of organizations and Human Resources. The results obtained will allow make the following contributions. First it will serve the research community in the AI field and its applications in the management of people and talent in organizations as a starting point for future related research work. Also important will be the implications for the people responsible by allowing the knowledge of the main uses and applications of new resources and tools in the HRM of organizations will also be relevant and current trends in their application.

Concept of Artificial Intelligence

The concept of AI has multiple definitions. Different researchers have proposed their definitions (Welsh 2019). Depending on the time and the level of technological development reached, different studies have focused on its various aspects. A sample of the most relevant definitions since the 20th century is shown in Table 1.

Despite the ambiguous origin of the concept of AI, two authors stand out in its development. On the one hand, we have A.M. Turing, the father of modern computation, while on the other hand, there is J. McCarthy, the father of AI. Turing (1937) introduced the concept of algorithms and laid the foundation of computer science. Later, Turing (1950) proposed the Turing test, which tests whether a machine has the capacity to be as intelligent as the person performing its functions. However, J. McCarthy coined the term “artificial intelligence” during a conference in Dartmouth (Paesano 2021). In the 1950s and 1960s, AI was expected to develop rapidly into computers and robots with human-level cognitive capabilities, but that did not happen until it recently gained prominence (Bolander 2019; Pillai and Sivathanu 2020).

Artificial Intelligence Applied to People Management

Human capital is a differentiating element of an organization as it is an intangible resource that is difficult for competitors to imitate, thus giving a potential competitive advantage to any organization (Kearney and Meynhardt 2016).

HRM has become a strategic trend in organizations due to economic, political, social, and especially technological changes (Jatobá et al. 2019). Not all departments have embraced this new role, and strategic positioning remains slow and sometimes problematic (Poba-

Nzaou et al. 2020). In these cases, incorporating technologies like AI requires the need to evolve with the other facets of society (Michailidis 2018).

The role of AI in an organization is to improve efficiency and effectiveness of the HR function by making the various management processes agile and accurate (Nankervis et al. 2021). For HRM, IA will enable the understanding and control of a data collection process so that this process is included in an organizational and economic efficiency strategy (Varma et al. 2022). Among the different areas that make up the HRM in an organization where AI is starting are: (1) talent search and recruitment, (2) training and development, (3) performance analysis, (4) career development, (5) compensation, and (6) staff turnover (Abdeldayem and Aldulaimi 2020; Nawaz 2020; Qamar et al. 2021; Yahia, et al. 2021)

Qamar et al. (2021) showed that AI has been implemented in HRM in various organizations via the following techniques:

Expert Systems: They are programs designed to configure expert knowledge into logical structures that solve unstructured problems and help develop complete information systems by providing easy access to knowledge. It is applied mainly in HR planning, compensation, recruitment, and labor management (Malik et al. 2022).

Fuzzy Logic: This technique is used in different research fields (Salmerón and Palos-Sánchez 2019). In the case of HRM, it's based on set membership levels, whose values vary between 0 and 1. A value of 0 indicates no membership, while a value of 1 shows full membership. With these sets, fuzzy logic can quantify data uncertainty and foresee future scenarios to facilitate decision-making (Kimseng et al. 2020). Its application began in 2000 and was used in personnel selection and optimal workforce design (Qamar et al. 2021).

Artificial Neural Networks: This application is a simplified model developed to mimic the function of a human brain. Its structure comprises a processing element, a layer, and a network to recreate the human learning process (Huang et al. 2006). It is one of the most popular techniques for prediction and is mainly used in selection, recruitment, and personnel performance management (Qamar et al. 2021).

Data Mining: It is the extraction of valuable but hidden information. Through its application, organizations can transform useful information and patterns into competitive advantages (Huang et al. 2006). Data mining was used in HRM in 2006 and has been applied mainly for recruitment, competency and performance evaluation, and talent management.

Genetic algorithm: These information search techniques based on replication, mutation, and gene crossover arrive at optimal solutions to mathematical problems. It is used mainly in workforce planning and personnel performance evaluation (Zhang et al. 2021).

Machine learning: It is the learning process by which a machine can learn by itself without being particularly programmed to do so (Răb-Kettler and Lehnervp 2019). Several papers agree that the use of machine learning in decision-making is quite beneficial for HR managers and turnover prediction (Hamilton and Davison 2022).

Benefits and Challenges of Artificial Intelligence in Human Resources Management

As with any technological advance, AI brings both benefits and challenges, and its application in HRM is no different (Vrontis et al. 2022). These can be approached from three points of view: employees, company, and society.

We highlight the following potential benefits:

Employees: The automation of repetitive and time-consuming tasks allows HR managers to focus on those tasks that add value and require unique skills and abilities (Pillai and Sivathanu 2020). The reduction or minimization of errors owing to machine learning also helps improve decision-making by providing more and better-processed information (Michailidis 2018). According to a 2019 survey, 61% of companies were using AI to improve HRM in key AI-transformed HRM areas. This task will include time-consuming and labor-intensive processes in recruitment, such as reading many CVs, sorting through them and identifying the best candidates and detect employees who need some training (Rykun 2019)

Company: For companies, AI means greater effectiveness and efficiency as it streamlines management processes and reduces associated costs (Nankervis et al. 2021). It enables greater candidate outreach as it reaches passive candidates who are not in active job search but might become interested in the position (Black and van Esch 2021). Another important element for companies is the improvement of communication and interaction possibilities among employees (Michailidis 2018). Research articles look at how AI help to improve the successive stages of the recruitment process: identifying, selecting and retaining talented people (Allal-Chérif et al. 2021).

Society: The creation of new professional profiles linked to AI, like robotics specialists, data scientists, deep learning experts, generate new scenarios which can benefit the public (Michailidis 2018).

As far as challenges are concerned, the following can be highlighted:

Employees: The application of AI may contribute to burnout, with some employees being worried about their career uncertainty, since machines may replace them, thereby creating anxiety and job insecurity (Kong et al. 2021). There is also dehumanization of personal relationships, as some of the HRM processes may be performed entirely by machines, like the use of chatbots (Fritts and Cabrera 2021). This implies the continuous need for training in technological matters. Finally, it is necessary to point out that the “techno-stress” is a consequence of excessive and continuous use of any type of technology (Malik et al. 2021).

Company: The need for highly qualified personnel to manage and acquire the necessary skills to keep up with the increasing technological developments (Abdeldayem and Aldulaimi 2020) is a reality in AI. Even though it has high implementation costs, it can reduce costs in the processes where they are applied (Michailidis 2018). Another challenge is the existence of biases due to the use of small and non-representative data volumes (Soleimani et al. 2022) and the increased exposure of the company leading to increased risk of its data security breach (Malik et al. 2021).

Society: One of the main challenges in this area is the “technology gap” Since technology in general and AI has divided the world, it has created greater technological inequality. This is because not all countries can implement and maintain technological infrastructure (Abdeldayem and Aldulaimi 2020). Potential job losses in certain professions are also important in the face of these challenges (Hamilton and Davison 2022).

Methodology

The methodology used was bibliometric analysis using the Bibliometrix application. This tool was developed by Aria and Cuccurullo (2017) to carry out comprehensive analyses of the scientific mapping of a topic. It is an open-source tool to perform a comprehensive analysis of the scientific literature. It was programmed in R language to be flexible and facilitate integration with other statistical and graphical packages. Bibliometrix enables the structured analysis of large amounts of information to infer: (a) trends over time, (b) which topics are being investigated, (c) changes in the boundaries of disciplines, etc., thus summarizing a topic (Guleria and Kaur 2021).

The first step was to determine the databases to be used for the document search. The databases being queried were Web of Science and Scopus, as they are currently the most relevant within our research field (Parris and Peachey 2013). The search keywords on both bases were “*Artificial Intelligence*” and “*Human Resources*” in the search field (Article Title, Abstract, and Keywords) (Macke and Genari 2019) for the period 2018–2022. This period was chosen based in previous authors. For Kshetri (2021) AI-based HRM applications can bring about significant changes in human resource management practices. However, previous researchers have observed a substantial gap between the promise and reality of AI in HRM (Michailidis 2018; Tambe et al. 2019). The research domain of AI in HRM is relatively nascent (Strohmeier and Piazza 2013). Garg et al. (2022) note the narrowing of the gap between the number of journal and conference papers from 2017 onwards: a decrease in conference papers with a simultaneous increase in journal papers shows the increasing confidence, interest, and acceptance for AI, especially Machine Learning (ML).

Based on all this, the choice was justified because (1) it had the highest number of publications on the issue, (2) it had an interest in the topic, and (3) the previous literature does not correspond to the current technological level.

Subsequently, the scientific fields selected for the query were (1) Business, (2) Management and Accounting, (3) Arts and Humanities, (4) Social Sciences, (5) Economics and Finance, and (6) Psychology and Research Management. These areas were chosen since they were directly related to our current scenario. The scientific fields that could contribute the least to research, such as physics, biology, medicine, etc., were eliminated. The analyzed works were those written in English to cover a larger number of publications (Gutiérrez and Maz 2004) and limited to those publications that were only articles (Podsakoff et al. 2005) excluding works corresponding to the following types of documents: (a) book, (b) book chapter, (c) proceedings paper, (d) review and (e) editorial material (Vlačić et al. 2021).

Once the search string was established and the corresponding filters applied, we obtained 156 articles. As shown in Figure 1, among the 89 articles initially obtained (63 in the Scopus database and 26 in Web of Science), 9 were rejected after further analysis of their content. This resulted in 80 valid articles for the study. Finally, 7 of these were eliminated as duplicates were found. Thus, we finally obtained 73 papers due to the harmonization of the results.

The final articles were exported from the databases in their respective formats; Plain text and BibTeX for Web of Science and Scopus, respectively. They were then integrated into a single format to be imported later into the Biblioshiny platform and further data analysis was carried out. Before processing the data with this software, the following steps were adopted: (1) Download and install the latest version of R and RStudio (<https://cran.r-project.org/> and <https://www.rstudio.com>) (2) Open RStudio and in the console window type the following command to finish the installation of Bibliometrix;

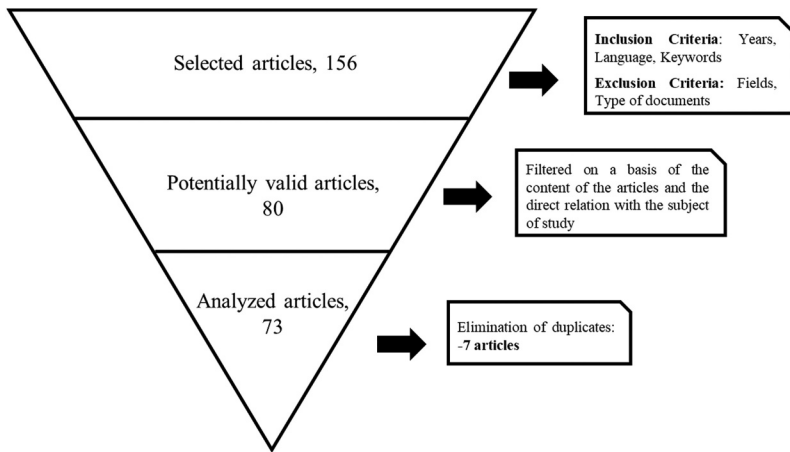


Figure 1. Identification of articles to be analyzed.

install. packages (“*bibliometrix*”) (3) Type the following command to be able to run the Biblioshiny program: *library (bibliometrix) biblioshiny ()*

According Iden and Eikebrokk (2013) and to the established inclusion and exclusion criteria the data extracted from each study were as follows: (1) the journal and full reference, (2) the authors and their institutions, (3) the countries where they were situated, (4) the keywords, (5) classification of the research methods, (6) theoretical frameworks and references theories used, (7) main topic area, (8) research questions and (9) a summary of the study.

The critical examination of the content of each article (Bellucci et al. 2021) together with the use of the Bibliometrix tool, in particular, by means of Multiple Correspondence Analysis (MCA), made it possible to establish three thematic clusters: (1) AI in HRM, (2) Digital Recruitment and (3) Electronic HR. According Paul et al. (2021) the systematic review of a topic in depth and with rigor favors both the theory on an area and the research methodology in that field can benefit, this is our purpose with the development of this work in the field of IA and HRM.

Results

AI is undoubtedly one of the most important innovations. Both academics and practitioners hope that IA can solve this problem and offer a solution to support and streamline innovation processes. However, the literature on this topic is fragmented (Pietronudo et al. 2022). These authors concluded that AI renews the organization of innovation and AI triggers new challenges. That is, they suggest that AI is not a tool that uniformly optimizes innovation management and decision-making but is better understood as a multifaceted solution.

Similar conclusions can be reached by first analyzing other systematic literature reviews (SLRs) and a bibliometric analysis. Table 2 shows SLR

works approach these reviews from different points of view applied to a greater or lesser extent to different HRM processes.

The 73 articles were published in 53 different journals and represented 199 different authors (Table 3). The average number of annual publications represents an average of < 1 article per year, thereby indicating, at first glance, that the field of AI being applied to HRM is underdeveloped. However, as shown in Figure 2, it is a topic of great interest in the immediate future.

The annual distribution of the number of articles shows the general state of research and trends, with exponential growth occurring only in the last five years. Advances and growth in the importance of AI in both academia and HR (Jatobá et al. 2019) have sparked increased interest in investigating the influence of one topic on the other. Although there were only two articles in 2017 addressing the concepts in a connected way, the number increased to 10 in 2019. The trend line shows that AI will soon persist in the future as one of the top world innovations (Qamar et al. 2021) with an annual growth rate: 64.38%.

Analysis of Sources

Table 4 shows, in order from the highest to the lowest number of articles, the main journals that published on these analyzed realities. The journal with the highest number was “International Journal of Manpower” with six articles, followed by the “International Journal of Human Resource Management” and the “Business Horizons” with five and four articles, respectively. The journals with the highest number of publications on these topics were journals related to business or technology, with a focus on HR, like “Advances in Developing Human Resources and/or Human Resources Management,” is also gradually gaining importance.

Another fundamental indicator called “Bradford’s Law” was used to analyze the main journals and their importance in the field (Bradford 1976). This law allows researchers to access those journals that provide the most information on a topic, thus reducing their search times (Figure 3).

Another fundamental indicator called “Source Growth” was used to analyze the main journals and their importance in the field. This figure allows researchers to know the evolution of those journals (see Figure 4). The journals “Ethics and Information Technology” and “International Journal of Human Resource Management” present an important growth trend.

The most cited journals were “Business Horizons,” “International Journal of Human Resource Management” and “International Journal of Manpower,” with 138, 87, and 12 citations, respectively (see Table 5).

The g-index is calculated from the distribution of citations of an author’s publications, which results in a set of articles ranked in decreasing order by the number of citations they have. The Hirsch index (h-index) uses the set of the author’s most cited articles and the number of citations it has received in other

Table 2. Previous AI and HRM Literature Overviews.

Authors	Type/Period	Data sources ^a	Context	Screened works/ primary studies	Methodology based
(Vrontis et al. 2022)	SLR unspecified	3,4	Holistic SLR on HRM strategies, namely: job replacement, human-robot/AI collaboration, decision-making, learning opportunities, and HRM activities: recruiting, training and job performance	45/187	(Tranfield, Denyer, and Smart 2003); (Crossan and Apaydin 2010)
(Votto et al. 2021)	SLR 2014–2020	1,3,5,6	Explore Tactical HRIS literature and come to understand which components are exist in literature and how they are further represented.	33/697	Tactical HRIS (T-HRIS) components
(Garg et al. 2022)	SLR 2002–2018	2	Semi-systematic literature review; understand current state of Machine Learning (ML) integration within HRM; showcase relationship between HR experts and ML specialists	105/168	(Wong et al. 2013) (Snyder 2019)
(Qamar et al. 2021)	SLR –July 2020	2	SLR of AI and HRM to capture current state-of-the-art and prepare for new research agenda	59/308	(Tranfield, Denyer, and Smart 2003) (Pickering and Byrne 2014)
(Di Vaio et al. 2020)	SLR/Bibliom 1990–2019	1,15	Comprehensive review of relationship between AI and sustainable business models, in special Sustainable Development Goals (SDGs). The SLR paper aims to highlight the role of Knowledge Management Systems (KMS).	73/88	Identify research gaps between knowledge management systems and AI

(Continued)

Table 2. (Continued).

Authors	Type/Period	Data sources ^a	Context	Screened works/ primary studies	Methodology based
(Basu et al. 2022)	SLR un-specified	1,5,6	AI – HRM Interactions and Outcomes: A SLR and Causal Configurational Explanation. Content analysis and thematic abstraction.	100/433	(Denyer and Tranfield 2009)
(Coron 2022)	SLR 2000–April 2020	7	based on an integrative synthesis of empirical and non-empirical articles on the use of quantification in HRM. Integrative and systematic synthesis procedure	94/103	(Briner and Denyer 2012)
(Bilan et al. 2022)	Bibliom.1983–2020	2	Bibliometric Review of AI Technology in Organizational Management, Development, Change and Culture	191/218	unspecified
(Bhatt and Muduli 2022)	SLR 1996–July 2021	8,9,10,11,12,13,14	AI in learning and development	81/115	(Tranfield, Denyer, and Smart 2003); (Crossan and Apaydin 2010)
(Pereira et al. 2021)	SLR 1995–2020	1,3	Impact of AI on workplace outcomes: A multi-process perspective. Limit to peer-reviewed journals ranked 3, 4 or 4* in the AJG (formerly ABS) 2018 journals.	56/211	(Tranfield, Denyer, and Smart 2003)
(Perello and Tuffaha 2021)	SLR 2010–may 2020	2,13	AI definition, applications and adoption in Human Resource Management	66/559	(MacKenzie et al. 2012); (Denyer and Tranfield 2009)

^a1: ISI Web of Science; 2:Scopus; 3: Business Source Ultimate (EBSCO); 4: Science Direct; 5: AIS; 6: ABI; 7: Journal Quality List (JQL) database; 8: Emerald; 9:Taylor & Francis; 9: Springer; 10: Sage Publications; 11: Massachusetts Institute of Technology Sloan Management; 12: Harvard business; 13: Science

Table 3. Summary of bibliographic information.

Description	Results
MAIN INFORMATION ABOUT DATA	
Period Time	2017:2022
Sources (Journals, Books, etc)	53
Documents	73
Annual Growth Rate %	64.38
Document Average Age	1.33
Average citations per doc	6.699
References	2511
DOCUMENT CONTENTS	
Keywords Plus (ID)	220
Author's Keywords (DE)	304
AUTHORS	
Authors	199
Authors of single-authored docs	13
AUTHORS COLLABORATION	
Single-authored docs	14
Co-Authors per Doc	2.93
International co-authorships %	8.219
DOCUMENT TYPES	
article	66
article; early access	4
review	3

publications. The m-index is defined as H/n , where h is the h-index and n is the number of years elapsed since the scientist's first publication (Aria and Cuccurullo 2017).

Analysis of Authors

Out of 199 authors, 187 published one article, nine published two articles and three published three articles. The authors J. Black, N. Nawaz and P. van Esch stand out (Table 6). K. Chaitanya and V. Prikshat V. start in 2021 his first article, having published a new paper every year since their first published article.

Regarding the impact rate of these authors, Table 7 shows that once again, the authors J. Black, N. Nawaz and P. Van Esch have the highest index (h-index of 2), which is double the average of the other authors, i.e., 1.

The affiliation of the authors is diverse, as shown in Table 8. Two universities stand out from the rest, i.e., University of Turin, Kingdom University and Auckland University of Technology, with the highest number of articles of four, three and two each, respectively.

The publication of articles from diverse countries reflects the subject's global importance. Seventeen countries published papers related to the application of AI in HRM (Table 9). The countries with the highest number of publications were the USA, India and China, with 13, 9 and 8 articles, respectively.

Although New Zealand is not the country with the highest scientific research output, it stands out after USA (Table 10), because its articles have

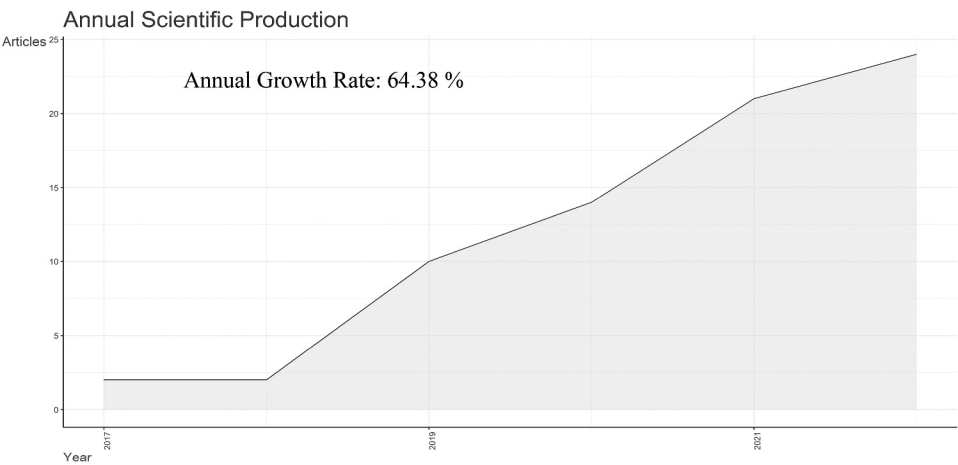


Figure 2. Annual evolution of publications.

Table 4. Sources with the largest number of related publications.

Sources	Articles
International Journal of Manpower	6
International Journal of Human Resource Management	5
Business Horizons	4
International Journal of Technology Management	3
Journal of Management Information and Decision Sciences	3
Advances in Developing Human Resources	2
Computers in Human Behavior	2
Ethics and Information Technology	2
International Journal of Scientific and Technology Research	2
Asia Pacific Journal of Human Resources	1
Benchmarking	1
BPA Applied Psychology Bulletin	1
California Management Review	1
Cyprus Review	1
Employee Responsibilities and Rights Journal	1
European Journal of Information Systems	1
Forum Scientiae Oeconomia	1
Frontiers in Psychology	1
Human Resource Management	1
Human Resource Management Review	1

the highest number of citations and therefore have the highest impact on the related scientific literature.

Analysis of Documents

The purpose of this study was to identify the most relevant and cited articles. Table 11 shows how Dabirian et al. (2017) is the article with the highest number of total citations. It has been cited 89 times, with an average annual citation rate of 14.83 citations. These authors argue that as employees use information technologies to openly share and access work-related experiences across organizations,

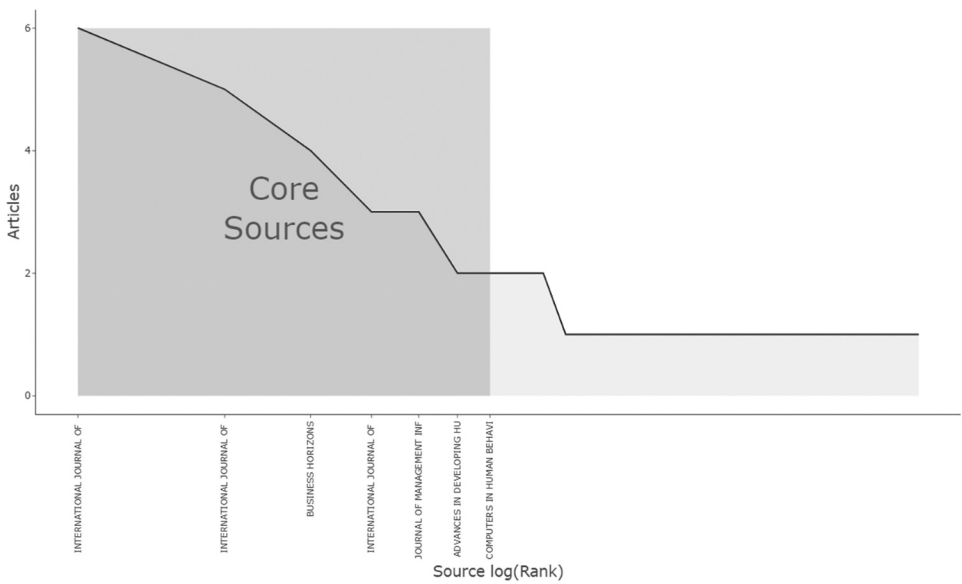


Figure 3. Bradford Law.

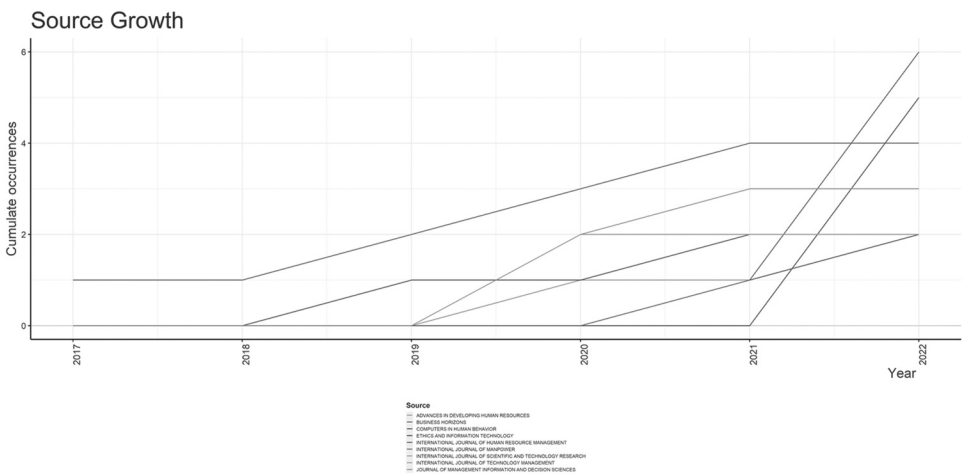


Figure 4. Source Growth.

their expectations and evaluations of workplaces change. Using a data collection of 38,000 reviews of the best and worst rated employers on Glassdoor, a crowdsourced online employer branding platform, they concluded that employers could use AI to become great workplaces that attract highly skilled employees.

Spectroscopic analysis: According to Marx et al. (2014), Reference Publication Year Spectroscopy (RPYS) is a quantitative method for identifying the historical origins of a research field. It creates a temporal profile of cited references for a set of papers, thus highlighting the period in which relatively

Table 5. Impact of sources.

Sources	h_indexx	g_indexx	m_index	TC	NP	PY_start
Business Horizons	3	4	0.5	138	4	2017
International Journal of Human Resource Management	3	5	3	87	5	2022
International Journal of Manpower	2	3	1	12	6	2021
International Journal of Scientific and Technology Research	2	2	0.667	14	2	2020
Journal of Management Information and Decision Sciences	2	2	0.667	4	3	2020
Advances in Developing Human Resources	1	1	0.333	2	2	2020
Asia Pacific Journal of Human Resources	1	1	0.5	4	1	2021
Benchmarking	1	1	0.333	12	1	2020
California Management Review	1	1	0.25	61	1	2019
Computers in Human Behavior	1	2	0.25	25	2	2019

TC: Total citations. PY_start: Year of publication start

Table 6. Relevant authors.

Authors (>=2 articles)	Articles	Articles Fractionalized
Black J.	3	1.50
Nawaz N.	3	2.33
van Esch. P.	3	1.50
Avrahami D.	2	0.50
Chaitanya K.	2	0.50
Chiappetta J. C.	2	0.45
Mcneese N.	2	0.45
Pessach D.	2	0.50
Prikshat V.	2	0.45
Schelble B.	2	0.45
Singer G.	2	0.50
Wang X.	2	0.67

Table 7. Author impact factor.

Authors	h_index	g_index	m_index	TC	NP	PY_start
Black J.	2	3	0.5	49	3	2019
Nawaz N.	2	2	0.667	4	3	2020
van Esch. P.	2	3	0.5	49	3	2019
Chulanova O.	1	1	0.25	5	1	2019
Abdeldayem M.	1	1	0.333	11	1	2020
Aggarwal V.	1	1	0.25	2	1	2019
Agrawal R.	1	1	0.5	1	1	2021
Aich A.	1	1	0.333	3	1	2020
Akar C.	1	1	1	2	1	2022
Akshay P.	1	1	0.333	1	1	2020

Table 8. Authors affiliations.

Affiliation	Articles
University of Turin	4
Kingdom University	3
Auckland Univ. Technol.	2
Clemson University	2
Coventry University	2
Lomonosov Moscow State University	2
Neoma Business School	2
Shandong University	2
University of Nicosia	2
University of Reading	2

Table 9. Scientific production by countries.

Country	Freq
USA	13
India	9
China	8
UK	4
New Zealand	3
Brazil	2
Denmark	2
France	2
Italy	2
Australia	1

Table 10. Average number of citations of articles by country.

Country	TC	Average Article Citations
USA	67	9.57
New Zealand	49	16.33
China	38	5.43
Italy	29	9.67
India	15	3.75
Denmark	7	3.50
Cyprus	6	6.00
UK	5	1.67
France	1	1.00
Poland	1	0.50

significant findings were published along with the temporal roots of a discipline.

Figure 5 shows how AI as a technology and its use in HRM has evolved and its interest in publishing-related work has increased. Spectroscopic analysis began in 1980, when related publications started appearing, although as depicted in Figure 5, it was not until 2017 that there was a notable increase in the related scientific production.

The first upturn occurred in 2000, and disruptive technology gained widespread importance during the early 2000s. Ever since then, changes have been observed in how organizations operate and how HRs are managed (Minbaeva 2021). Until the early 1980s, 70–90% of the company's value was linked to tangible assets. However, since 2000, the value linked to intangible assets has increased to 65%, with people being the “cogs in the wheel of intangible assets” (Black and van Esch 2021). Two AI techniques are being used in HRM: fuzzy logic and artificial neural networks, both of which aid in the optimal workforce design and performance management.

The second upturn occurred in 2006 when knowledge management became a field of greater importance even though it was already being studied. Since intangible factors had already become more important, there was a greater need for HRM to obtain competitive advantages. Using data mining will be the

Table 11. Most cited articles.

Article (Authors/Journal)	Total Citations	TC Per Year
(Dabirian et al. 2017)/Business Horizons	89	14.83
(Tambe et al. 2019)/California Management Review	61	15.25
(Vrontis et al. 2022)/The International Journal of Human R. M.	51	51.00
(Caputo et al. 2019)/Management Decision	29	7.25
(Black and van Esch 2020)/Business Horizons	26	8.67
(Suen et al. 2019)/ Computers in Human Behavior	24	6.00
(van Esch and Black 2019)/Business Horizons	21	5.25
(Gupta et al. 2018)/Journal of Information Technology Teach Classes	17	3.40
(Malik et al. 2022)/The International Journal of Human R. M.	16	16.00
(Giermindl et al. 2022)/European Journal of Information Systems	14	14.00
(Pan et al. 2022)/The International Journal of Human Resource M.	14	14
(Pillai and Sivathanu 2020)/Benchmarking	12	4
(Abdeldayem and Aldulaimi 2020)/Internatio. J. of Scientific & T. R.	11	3.67
(Kong et al. 2021)/International Journal of Contemporary H. M.	9	4.5
(Arslan et al. 2022)/International Journal of Manpower	9	9
(Ogbeibu et al. 2022)/Journal of Intellectual Capital	9	9
(Michailidis 2018)/Cyprus Review	6	1.2
(Vinichenko et al. 2019)/International Journal of Recent T. and E.	5	1.25
(Sahota 2019)/IEEE Engineering Management Review	5	1.25
(Boustani 2022)/Journal of Asia Business Studies	5	5

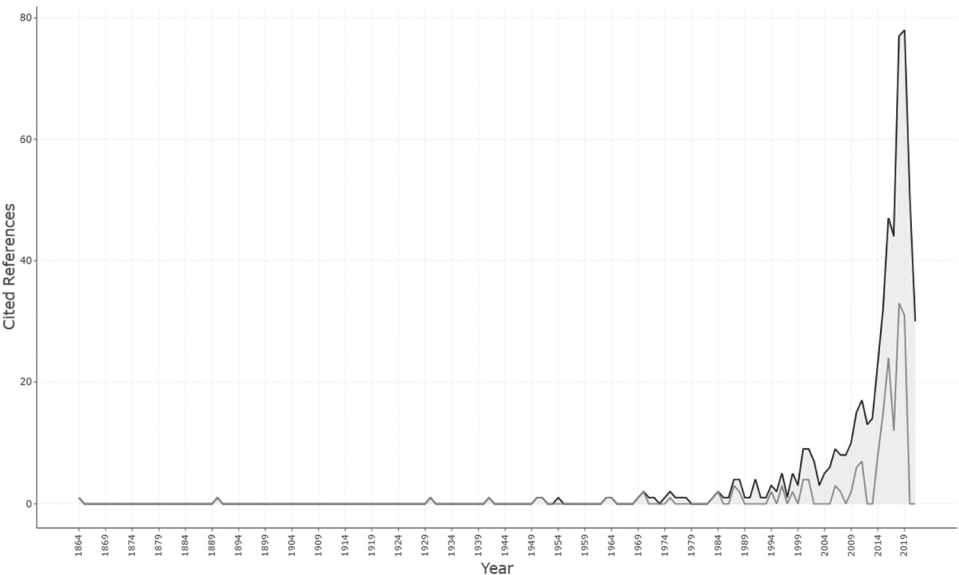


Figure 5. Annual Spectroscopic Analysis of publications.

key to correctly assessing competencies and performance. Through these evaluations, it will promote the exchange of knowledge among employees, along with the generation of new ideas and business opportunities.

Finally, the greatest upturn occurred in 2018, since it is from this year that the study on AI being applied to HRM began gaining importance. The endless possibilities of AI automation generate interest in its application in HRM (Jatobá et al. 2019).

Keyword analysis: Keywords are essential for a bibliographic search. Their identification and analysis are crucial for gaining in-depth knowledge of the articles' content and the topics being analyzed.

The most impactful frequent keywords related to AI application in HRM are AI, HR, Management, and Machine Learning. The importance of the AI concept stands out, but to a lesser extent than that of HRM. AI is experiencing an increase in its application in various fields, but as far as HRM is concerned, it has not yet occurred completely.

Knowledge Structures Analysis

Conceptual structure: It refers to what the science is about, the main themes, and trends. Specifically, multiple correspondence analysis (MCA) helps analyze categorical data to reduce large sets of variables into smaller sets to synthesize the information in the data (Mori et al. 2014). To do this, the data are compressed into a low-dimensional space to form a dimensional or three-dimensional graph that uses planar distance to reflect the similarity between keywords.

Three clusters or groups of content are highlighted:

- (1) **Cluster 1 (AI in HRM):** In this first cluster, the AI tools being applied in HRM are addressed to highlight big data and machine learning. With big data, this might support decision-making processes, since large amounts of varied data from various sources can be quickly analyzed, resulting in a stream of actionable knowledge (Caputo et al. 2019). As for machine learning, the last decade has accelerated its use and applicability owing to the availability and variety of data (Hamilton and Davison 2022). This type of learning provides systems with the ability to learn (Soleimani et al. 2022) and mimic human skills (Bolander 2019). Machine learning can learn from the current context and generalize what it has learned to a new context. There are many organizations that, despite not comprehensively using AI in HRM, use this type of algorithm (Nankervis et al. 2021).
- (2) **Cluster 2 (Digital Recruitment):** It is the use of ICTs to attract potential candidates, keep them interested in the organization during the selection processes, and influence their employment choice decisions (Johnson et al. 2021). Pillai and Sivathanu (2020) point out how talent acquisition has become a crucial function for HR managers, with organizations going to great lengths to attract the best talent.

For van Esch and Black (2019), talent acquisition has changed from a tactical HR activity to a business priority. The basis of competitive

advantage has shifted from tangible assets to intangible assets, thereby increasing the strategic importance of human capital to make it the key driver. The shortage of talent in the labor market has intensified the need for human capital.

The traditional method of searching for candidates used to be a slow and costly process. However, today, due to technological advances and digital recruitment, it is much easier and cheaper. Furthermore, since nowadays most of society is spending increasing time in the digital space, if companies want to attract and recruit talent, they have to do it in that space (Black and van Esch 2021).

3) Cluster 3 (Electronic HR): This cluster presents a much more “futuristic” vision of HR which involves complete digitalization and the use of robots in daily functions.

While electronic HR management stands out in using technology to facilitate HRM processes like, recruitment, selection, training, performance management, human resource planning, compensation, etc. (Johnson et al. 2021). Through ICTs, it is possible to achieve better control of performance and over the employees’ behavior for greater strategic and effective management.

Using robots in HRM also stands out. Future forecasts are that in 20 years, robots will be in charge of making some analytical decisions that are now being made by human managers, while humans will continue to be in charge of tasks like creativity (Stanley and Aggarwal 2019).

Social structure: It shows how authors or countries are related in a research field; the most commonly used is the co-authorship network (Aria and Cuccurullo 2017). The authors who stand out for having the highest number of shared publications are Black & van Esch and McNeese & Schelble. In general terms, there is a high degree of cooperation between authors in the publication of articles, and very few publications are being written by a single author.

In terms of collaboration between countries, the USA is the country with the highest number of collaborations. Whereas with New Zealand and with France, it should be noted that collaboration with the first country is much greater than with the second. Also, there are other collaborations between Brazil and Portugal, China and the United Kingdom, Germany, and Norway-Tunisia.

Discussion

The research questions initially raised after the results were obtained and the studies analyzed can be answered as follows.

Q1: AI is not yet commonly used in HRM. However, its use has acquired greater relevance in the last five years, with 2021 being the year with the highest number of publications. Authors like Cappelli et al. (2019) assert

that the application of AI in HRM has not advanced as expected. Among the main barriers are: the complexity of HR phenomena, associated data challenges, equity and legal constraints, and employee reactions. Poba-Nzaou et al. (2020) states that even though the “Fourth Industrial Revolution” again highlighted the need for people to be at the center of organizations, it seems that HR departments remain unprepared to take advantage of this new opportunity. Nankervis et al. (2021) point out that as technology advances, it will be impossible for the traditional HRM approach to not advance as well; in fact, the forecast is that over the next decade there will undergo a significant change. However, any research article indicates that social entrepreneurship will use the opportunities of Industry 4.0 to optimize its processes until 2030, but will decline complete automation, using human intellect and AI at the same time (Popkova and Sergi 2020)

Q2: The results obtained show that the literature has largely focused on the analysis of the application of AI in personnel selection. Qamar et al. (2021) pointed out that, although AI is becoming increasingly important for HR, instead of trying to take advantage of this tool to apply it to the entire people management process, they focused only on a specific sub-area. It is meaningless to attract the best talent if you don’t have the tools to manage it. As highlighted by Nankervis et al. (2021), the automation of certain complex processes will require increasingly highly trained and qualified personnel.

Q3. The reviewed literature highlights that most employees still do not welcome the application of AI in HRM. Nankervis et al. (2021) show that many HR professionals lack the necessary skills and competencies to meet the challenges of AI application in HR processes, hence their possible contrary attitude. Fritts and Cabrera (2021) highlighted the concern of HR professionals against the use of recruitment algorithms, as they can dehumanize the hiring process. Vinichenko et al. (2019) highlighted how many employees lacked confidence in the integrated use of machines in the management processes because they feared being replaced by machines. However, this is unlikely, since even if some tasks are fully automated, the human factor will not disappear completely (Johnson et al. 2021; Kong et al. 2021).

Q4. A company gaining a competitive advantage involves several factors like customer satisfaction through quality service, cost optimization, innovation, productivity, etc. The primary function of any technology, specifically AI, is to improve the efficiency and effectiveness of the HR function to help make recruitment, retention, and management easier and more accurate, automate repetitive tasks, and reduce labor costs (Nankervis et al. 2021). The innovation processes is a strategical practice in business companies (Bonilla-Chaves and Palos-Sánchez 2022)

All this will result in an innovative organization full of talent with high labor welfare, which will provide quality service to customers, obtain customer

satisfaction, and lead to higher productivity. It has also been observed that the use of AI helps predict staff turnover to avoid the reduction in productivity derived from it.

Theoretical Contributions

Our study contributes significantly to the literature on IA and HRM implications. It is noteworthy how we introduce the framework of previous research on AI and HRM. Through the results obtained by applying the methodology of bibliometric analysis and systematic review of the literature, it has been possible to ascertain the relative and insufficient attention by the academy to these two phenomena together.

Given the lack of similar studies applying bibliometric analysis in this field of study, it can be the first starting point on the same. This will help future researchers as a reference point for expanding and developing the content of this study. It can also be useful for those in HR who want to investigate and learn more about the subject and analyze the current situation to have a minimum number of references in case they want to enter this world.

Practical Contributions

Also important are the practical implications derived from the results of this work for the management and administration of organizations, specifically for HRM. The results obtained provide some very important ideas that can be of great use to HR managers and experts related to the area to understand what the main behaviors and trends have been so far when companies adopt HRM connected to IA.

As noted Pan et al. (2022), an important fact is a need for managers of organizations to encourage the development and implementation of specific resources in the field of AI in such a way that the adoption of AI in the company is favored.

Limitations and Future Research

This research work, like others, is also subject to a series of limitations. The main limitation has been marked by the dispersion of information and, sometimes, limited to particular issues that do not favor a general view of the topics in a connected way.

Research Agenda

Regarding the main lines of research derived from this work, it is important to highlight the relevance of conducting studies that focus not only on the

application of AI in the recruitment and selection of personnel, but also on the rest of the areas in HR management. It would also be opportune to conduct studies that analyze AI's effect on HRM in the employees of organizations.

Conclusions

The most relevant conclusions derived from the results obtained and their analyses are:

First, there has been an extraordinary development in technology in recent years, especially AI. Despite its development, importance of its impact in the HRM field has not been as expected. AI application in HRM is a very specific field of study, since most of the research has focused on its application in the recruitment and selection of personnel, besides important functions like training, development, or personnel rotation. There is indeed an increasing interest in talent and the recruitment of highly qualified personnel, which is necessary for facing the changing environment and high competition. But it should be noted that talent must not only be found, but also maintained and developed to turn it into a competitive advantage. For this reason, it is essential to use AI technologies in other functions and extract the maximum added value from each process.

Second, based on the results obtained, it can be seen that there are still fears and negative feelings in HR employees and managers about the AI application. These feelings can complicate or slow down the use of AI in this area. Although technology has strongly disrupted the labor market and has helped create new businesses and develop existing ones, it has also eliminated many others, thus causing greater concern. But it should be noted that AI technologies need people for their proper management. Despite being faster, working 24 hours a day, optimizing time and tasks, etc., AI does not have the essential soft skills for any work environment.

Like any new technology, AI has its strengths and weaknesses. This makes it essential for HR departments to carry out an effective AI implementation strategy to integrate it safely within organizations, thus eliminating the potential damage. It is obvious that in the long term, the use of disruptive technologies will no longer be optional but rather necessary to remain competitive among other organizations; otherwise, they will lose their market positions or worse, will disappear.

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